REPORT 10

SWEEP

SOIL AND WATER

ENVIRONMENTAL

ENHANCEMENT PROGRAM

PAMPA

PROGRAMME D'AMÉLIORATION

DU MILIEU PÉDOLOGIQUE

ET AQUATIQUE

Canada

Ontario

SWEEP

is a $30 million federal-provincial agreement, announced May 8, 1986, designed to improve soil and water quality in southwestern Ontario over the next five years.

PURPOSES

There are two interrelated purposes to the program; first, to reduce phosphorus loadings in the Lake Erie basin from cropland run-off; and second, to improve the productivity of southwestern Ontario agriculture by reducing or arresting soil erosion that contributes to water pollution.

BACKGROUND

The Canada-U.S. Great Lakes Water Quality Agreement called for phosphorus reductions in the Lake Erie basin of 2000 tonnes per year. SWEEP is part of the Canadian agreement, calling for reductions of 300 tonnes per year — 200 from croplands and 100 from industrial and municipal sources.

PAMPA

est une entente fédérale-provinciale de 30 millions de dollars, annoncée le 8 mai 1986, et destinée à améliorer la qualité du sol et de l'eau dans le Sud-ouest de l'Ontario.

SES BUTS

Les deux buts de PAMPA sont: en premier lieu de réduire de 200 tonnes par an d'ici 1990 le déversement dans le lac Erie de phosphore provenant des terres agricoles, et de maintenir ou d'accroître la productivité agricole du Sud-ouest de l'Ontario, en réduisant ou en empêchant l'érosion et la dégradation du sol.

SES GRANDES LIGNES

L'entente entre le Canada et les États-Unis sur la qualité de l'eau des Grands Lacs prévoyait de réduire de 2 000 tonnes par an la pollution due au phosphore dans le bassin du lac Erie. PAMPA fait partie de cette entente qui réduira cette pollution de 300 tonnes par an — 200 tonnes provenant des terres agricoles et 100 tonnes provenant de sources industrielles et municipales.

100-05204/

AN ECONOMIC EVALUATION

OF

TILLAGE 2000 DEMONSTRATION PLOT DATA

(1986-1988)

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OF THE

SOIL & WATER ENVIRONMENTAL

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However, the views and opinions contained herein are those of the authors and do not necessarily reflect the views of Agriculture Canada or the SWEEP Management Committee.

EXECUTIVE SUMMARY

Deloitte Haskins & Sells undertook an evaluation of the costs and returns associated with a range of conventional and conservational tillage practices incorporated in the Tillage 2000 program.

The analysis incorporated results from 1986 to 1988 for corn, soybeans, winter wheat and barley.

Key findings are that:

- Reduced (minimum) tillage practices produced generally higher yields and higher net returns per acre in corn, barley and winter wheat than conventional practices.

- No till practices typically resulted in lower yields and higher direct input costs per acre for all crops. At the same time, significant machinery and labour savings resulted in higher net returns to no till than conventional or reduced tillage in winter wheat and equivalent net returns to conventional practices in corn.

- No till and reduced till practices also had the same or a higher level of probability of achieving the same level of net returns in corn as conventional practices. That is, there was no greater level of financial risk in using reduced or no till practices relative to conventional practices.

- High returns to labour for the no till and reduce tillage practices are evident and could well prompt farmers with high "opportunity costs" to labour to beneficially switch to these practices.

That is, farms with, for example:

a) labour shortage or difficulties at key work times;
b) higher returns to labour inputs in other enterprises eg. dairy; and
c) high returns from expanding the crop enterprise or the total farming enterprise.

ACKNOWLEDGEMENTS

Deloitte Haskins & Sells would like to express their appreciation to OMAF and to Doug Aspinall in particular for providing the necessary data for the research. We would also like to acknowledge the funding provided by Agriculture Canada as part of the ongoing SWEEP project and the support and input from Rick Seguin.

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1.0 INTRODUCTION

Deloitte Haskins & Sells has developed a data management system, and economic evaluation models for the SWEEP program. The availability of the Tillage 2000 data provided an opportunity to test the proposed data management and economic analysis models.

The Ontario Ministry of Agriculture and Food (OMAF), the University of Guelph, and the Ontario Soil and Crop Improvement Association have worked in a cooperative effort to test a variety of soil conservation tillage practices on selected farms in southwestern Ontario, from 1986 to 1988. This program, commonly referred to as Tillage 2000, is part of SWEEP. Detailed data on both inputs and outputs has been compiled for three years on a field and cooperator basis. The nature and type of data collected conforms closely to the data that will be collected in the SWEEP-PDW program. This compiled data was made available to Deloitte Haskins & Sells for two objectives:

1. To test the data management system and economic evaluation models developed by Deloitte Haskins and Sells for the farm level economic impact assessment of alternative soil conservation practices. The following criteria were important to this study element:

    a) Ease of operation.

    b) Accuracy of results generated according to expected "logical" reasoning.

    c) Assessment of need for model refinements in order to facilitate the operation and interpretation of SWEEP data and results.

2. To provide stakeholders with preliminary economic evaluation results of Tillage 2000 in a manner that will be consistent with the results to be generated for the rest of the SWEEP program.

2.0 TILLAGE 2000 DATA BASE

The Tillage 2000 data provided to Deloitte Haskins & Sells represents 35 producers over three years and across 11 crops, including the following:

corn	
soybeans	canola
winter wheat	corn silage
barley	mixed grains
oats	spring wheat
winter barley	wheat (unspecified)

Sufficient data for a meaningful economic analysis was available for only four of the above crops, namely: corn, soybeans, winter wheat, and barley. Information for all other crops was processed into the data management system, to test the full data management capabilities of the program, and is available upon request.

A variety of tillage classifications/practices are reported for each field. Upon consultation with OMAF personnel, it was decided to classify all tillage practices into one of three categories, thus making the economic evaluation and comparison of alternative practices more manageable and meaningful for interpretation. The three tillage practice classifications used in this analysis are:

1) CONVENTIONAL TILLAGE: - utilizing fall and/or spring plowing operations with traditional moldboard plows, which attempt to completely overturn the soil and leave little crop residue.

2) REDUCED TILLAGE: - utilizing tillage operations with equipment that only partially overturns the soil yet leaves some greater amount of crop residue compared to conventional tillage.

3) <u>NO-TILL</u>: - as the name implies, this means that fall or spring tillage operations are not performed in separate operations, thus leaving the greatest amount of crop residue.

Data were initially provided to Deloitte Haskins and Sells by farmer, crop, and year. Each input/output data sheet provided information on the type and date of operations, materials used, duration of each operation, type of labour used (i.e. owner, hired, or custom), and an inventory of tractors and machinery used by operation. The tractor/machinery listing indicated the purchase price, date of purchase and/or age, fuel consumption per hour, and type of fuel used (i.e. gas or diesel).

The Tillage 2000 data is based on "paired" comparisons. That is, side-by-side demonstration comparisons were performed consisting of various combinations of conventional vs. reduced tillage, conventional vs. no-till, no-till vs. reduced tillage, or a combination of the three. From an economic analysis perspective, the Tillage 2000 data (1986-88) can be organized two ways as follows:

1) maintain the "paired" observations, and for each tillage practice combination include only those fields which fall under each category for each year. For example, if comparing the results of conventional vs. reduced tillage, only the conventional fields for which a matching/corresponding reduced tillage field is present are included in the average calculation and vice versa. The same would hold true for all other paired comparisons.

2) aggregate all field data into either conventional, reduced or no-tillage practices and conduct the economic analysis across all fields by category regardless of the existence of "paired" comparisons.

There are advantages and disadvantages of each approach. With the first approach, a more accurate estimate of the difference in each paired comparison is provided. However, it is less accurate to directly compare results of conventional, reduced and no-till in a three-way comparison. Specifically, this first approach permits one to answer the following questions:

1. How do reduced tillage practices compare to conventional tillage practices?
2. How do no-till practices compare to conventional tillage practices?
3. How do no-till and reduced tillage practices compare?

By utilizing the second approach, (i.e. aggregate all crop data into three tillage practices for 1986-88) one can address the following questions more accurately:

4. On average, what can a farmer expect in net returns from no-till practices compared to either reduced or conventional tillage practices, or vice versa?
5. What is the range of variability associated each tillage practice, if all field results are taken into account?

The disadvantage of this second approach is that more variability in responses is introduced due to differences in soil types and other locational differences. The utilization of Monte Carlo simulation is useful in this regard to assess the financial risk associated with each alternative tillage practice.

For the analysis of corn data only, both analytical approaches were used. For the remaining crops, only the second analytical approach was followed because of the scarcity of data over the study period. For these latter crops, it was considered best to utilize all data/observations regardless

of available paired comparisons for the simple reason that it is likely farmers would be more interested in answers to questions 4 and 5 above[1].

All Tillage 2000 input/output data sheets were reviewed with J.D. Aspinall, coordinator of Tillage 2000, to ensure proper interpretation and to review and update missing data files. Deloitte Haskins & Sells did not attempt to verify the accuracy of the reported data, rather to ensure that data files were complete.

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1 Indeed the results presented later in this section indicate only a marginal difference in results for corn when analyzed with either approach.

3.0 DATA INPUT AND MANAGEMENT

The data management system designed by Deloitte Haskins & Sells to coordinate and manipulate large volumes of field level information from SWEEP was utilized for this task. This data management system was generated with DBASE III[2]. All field level information from Tillage 2000 was coded and key-punched manually into computer files. The following data files were constructed upon completion of this exercise:

1) General farm information - including farmer name-code, crops grown, acreage, and location.

2) Machinery inventory - including farmer name-code, machine brand and model, horsepower where relevant, fuel type, age of machine, purchase price, year purchased, unit width if relevant, average annual use, expected life.

3) Operations performed - by date, kind of operation, type of labour used, time required to complete operation, and amount of fuel used.

4) Machines used by operation - listing of machinery use by operation as a basis to determine operation costs.

5) Material inventory - description of type and quantity of material used per operation by field.

The above data files can be printed in report format as requested.

Several problems arose with the data provided which tended to complicate the data input process, including but not necessarily limited to the following:

a) There was lack of consistency in the recording of machinery costs and purchase price and age. Specifically it was not clear whether machinery listed was new or used and whether the age was actual or the period owned.

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[2] The file structures and their descriptions are provided in the second annual report.

Without this information, the calculation of machine costs per hour were difficult.

b) There were many missing values and dates for operations performed. Consequently, in-office estimates were made in a number of cases, particularly if operation dates were missing an estimate of timing was made. This could result in some operations being mis-allocated to fall or spring operation summaries.

c) In some cases, additional operations were considered missing.

d) There were missing values for machinery provided to cooperators free of charge from the program. To provide an accurate cost comparison between tillage practices, it is necessary to have the market value for this equipment since in commercial practice they will comprise part of the operation cost.

e) The definition and recording of some tillage practices was not well documented.

f) There were missing data for materials used in some instances.

As data was being keypunched into the computer, several refinements to the original DBASE III program were necessary to accommodate differences in the way input/output data will be recorded. For example, if a farmer conducts an operation one day with one set of equipment and completes it another day with a different set of equipment, the data management program must be sensitive to this change. Previously, the program did not accommodate this change. Similarly, many other minor refinements were required as needed.

In total, the data input process and data management program refinements took the greatest amount of time to complete compared to other tasks in this evaluation. None-the-less, the experience of working with the Tillage 2000 data was extremely valuable. Specifically, when SWEEP data is available, little or no time will be lost in the economic

analysis, consequently enabling a faster turn around of results.

4.0 DATA CALCULATIONS/MANIPULATIONS WITHIN DBASE III

Within the data management system, several calculations were made based upon the imputed data. The first calculations were tractor and machinery costs per hour. These calculations were dependent on a series of previous calculations including: depreciation, interest, insurance and housing, and repairs and maintenance. All calculations were based upon the guidelines outlined in "Cost of Owning and Operating Farm Machines", OMAF Agdex 825, June 1984.

The data used for these calculations were:

- purchase price, as provided by Tillage 2000 cooperators
- age or year when purchased
- interest rate of 12%
- estimated total annual hours of use for all farm operations

An alternative to "purchase price" for all tractors and machinery was utilized, namely: "current market value" or "trade-in value", in a second machinery cost calculation. This was done for two reasons. First, there was a wide variation in the type/cost and age of equipment used by cooperating farmers in Tillage 2000.

This resulted in significant variation in machinery costs per acre as reported in previous OMAF publications of Tillage 2000 economic analysis results. Specifically, a farmer using a relatively old complement of farm machinery could obtain different net return results from various tillage practices compared to another farmer with a new machinery complement, simply based upon the cost of conducting the same operations.

Consequently, an alternative method was required to account for these differences in machinery complements between farmers. For example, older equipment was valued at current market values using the Official Guide of current market values for tractors and machinery published by the Retail Farm Equipment Dealers Association. These new current market values were used in place of purchase price and assumed to be in year 1 of use, hence depreciation costs were determined in all cases. A similar process was conducted for newer equipment. This resulted in a narrowing of the cost spread between new and older machinery complements.[3]

Secondly, we believe that using current market values for machinery provides a better approximation of the "opportunity cost" of performing the operations. In this sense, it provides a more realistic cost comparison and decision making framework for farmers to consider. The impact of this alternative approach was to lower the machinery cost component somewhat and narrow the range of cost variability between farms.

Other data calculations conducted within DBASE III were:

- sum of fuel use by operation
- sum of hours to complete each operation
- total material costs per field categorized by: herbicide, seed, fertilizer, insecticide, and other

All data calculations within DBASE III were conducted to provide direct input into the financial analysis component of this study. The methodology for the financial analysis is presented in the next subsection.

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[3] The reason for this is that the OMAF guide to calculating farm machinery costs uses the straight line method of depreciation, which tends to accentuate the farm machinery cost differences between new and older equipment.

5.0 THE ECONOMIC EVALUATION MODEL - FIELD LEVEL

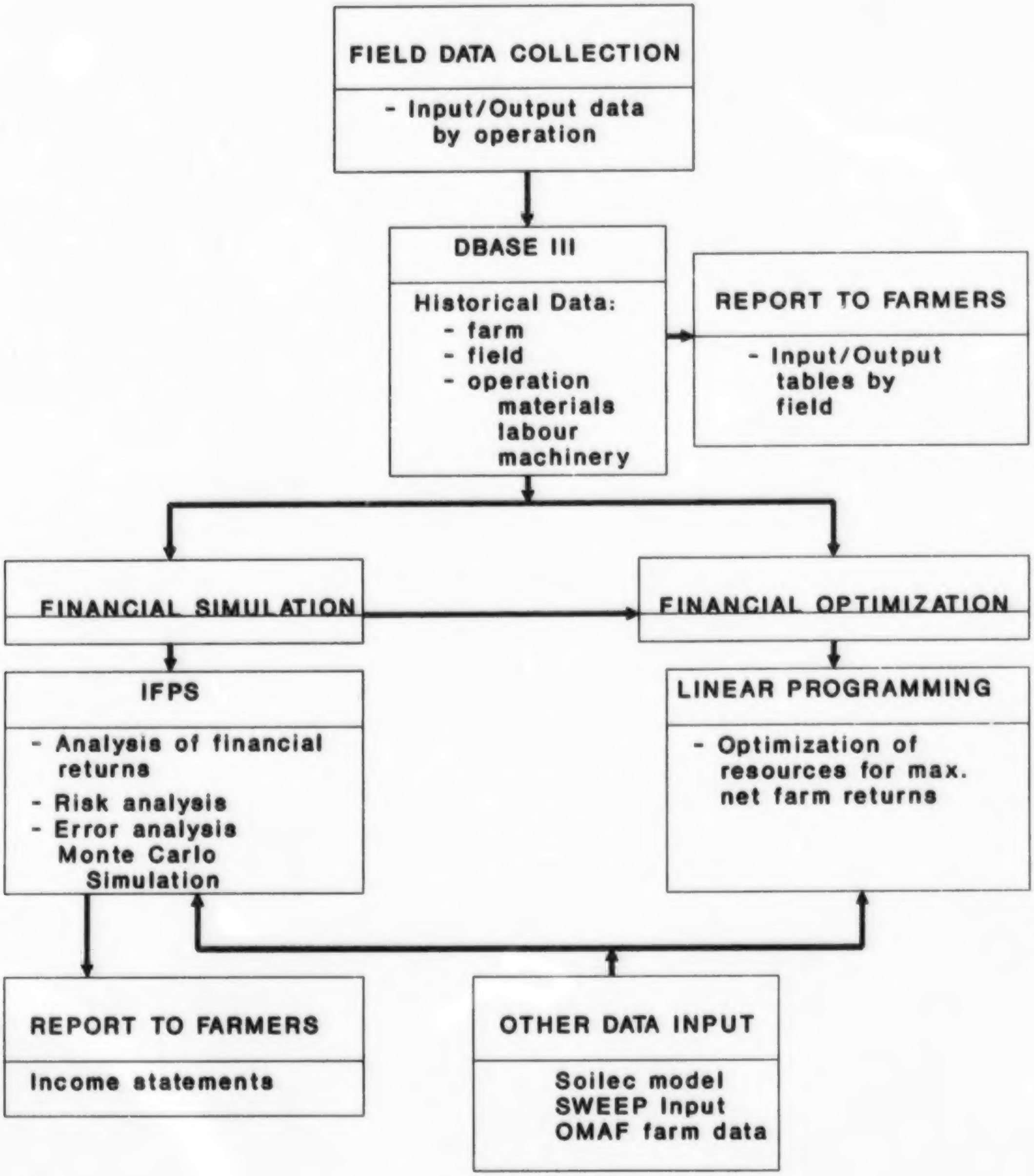
Within SWEEP, the overall economic evaluation is comprised of two elements, namely: 1) a financial simulation of field and farm level impacts; and 2) financial optimization using linear programming to indicate the optimum mix of resources for maximum net farm returns, (Figure 5.1).

The intent of this exercise is to conduct a financial simulation of field level impacts resulting from various tillage practices. Specifically, the objective is to examine the net economic impacts associated with alternative tillage practices, using the following measurements:

1. net returns per acre, and
2. net returns per labour hour.

To facilitate this quantification, partial budget models were constructed within IFPS (Interactive Financial Planing System). A unique, yet similar IFPS model was constructed for each crop (4) and whether utilizing purchase price or current market value (trade-in value) for machinery used.

FIGURE 5.1
OVERVIEW OF THE METHODOLOGICAL PROCEDURE FOR ECONOMIC EVALUATION OF SOIL AND WATER QUALITY CONSERVATION TECHNOLOGIES



The financial analysis is comprised of the following components:

a) The machinery and/or custom costs associated with conducting fall, spring or harvest operations per field.

b) The material costs (MA) per field. (Each field represents either one of the following tillage practices: 1-conventional tillage; 2-reduced tillage; and 3-no-tillage.)

c) Fuel costs per field.

d) Paid labour costs (LC) per field.

e) Total costs (TC) per field, including all the above, (i.e. total variable costs and machinery/tractor or custom costs associated with field operations only).

f) Total time (hours) to complete all operations.

g) Crop yield and total revenue per acre.

h) Net margin on a per acre basis - 2 measures:

   A) Revenue minus total costs (TC)

   B) Revenue minus material costs (MA)

i) Net return per labour hour, (including labour costs).

Given the sensitivity of results to variability in yields and material costs per acre under alternative tillage systems, a Monte Carlo simulation of the financial analysis was conducted for corn only[4], (utilizing the second approach for data organization described earlier), as per the discussion in our first and second annual report.

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[4] Corn was the only crop for which sufficient data/observations were available to estimate mean and standard deviation parameters for all tillage types by year.

6.0 RESULTS AND DISCUSSION

The Tillage 2000 data was aggregated into 12 crops across 3 production years. In addition, the cost of machinery for operations performed was calculated two ways, as per Section 4.0, consequently 24 crop models were generated for this analysis. This section reports the results of two calculations: A) the comparison of net returns per acre between alternative tillage practices for each crop in a static partial budget analysis; and B) the probability distribution associated with alternative tillage practices for corn production only. The latter analysis was conducted for corn only since it contained sufficient observations for enabling a meaningful Monte Carlo simulation.

6.1 Comparison of Net Returns Between Alternative Tillage Practices

This section summarizes results from the comparison of net returns between alternative tillage practices within a partial budget framework and analysis. Results are presented by crop, separately, for each of the following tillage practices:

1. Conventional Tillage
2. Reduced Tillage
3. No-Till

Results for corn production are presented first utilizing the second ("unpaired") aggregate approach to organizing the field input-output data, followed by the results based on the "paired" analysis of the data.

6.1.1 Grain Corn

Field scale input/output data for corn was the most common and was provided from 24 cooperators from 1986 to 1988 as follows:

	1986	1987	1988	TOTAL
1. Conventional	11	13	5	29
2. Reduced Tillage	13	17	9	39
3. No-Till	8	8	6	22
Total	32	38	20	90

In total, data from 90 corn fields were provided[5]. In most cases, participating farmers had side-by-side comparisons of either conventional and reduced tillage systems, or conventional and no-till systems, or reduced tillage and no-till systems. In only a few exceptions were side-by-side comparisons conducted for all three at once. Moreover, only a few cooperators participated for all three years with exactly the same tillage comparison. Consequently, the field input/output data is highly variable within tillage practice categories, when the data is organized in this way.

The net returns per acre (revenue - total costs) from reduced tillage exceed net returns for conventional and no-till, regardless of the method for valuing farm machinery (see Tables 6.1a and 6.1b). Using current market values (or trade-in values), net returns from reduced (minimum) tillage tended

[5] It is our expectation that SWEEP data will be provided in imperial units as well.

to exceed conventional and no-till by $18 and $20/acre respectively, (Table 6.1b). Similarly, net returns from reduced tillage was some $23 per acre greater than conventional and $15 per acre greater than no-till using purchase price basis of calculations depreciation. Consequently, there appears to be only a minor difference in net returns per acre between conventional and no-till practices on corn. The use of trade in values to calculate depreciation charges reduced net return per acre for no-till relative to conventional by $10 per acre.

The marginal analysis criteria does not account for the opportunity cost of labour, yet is often the most cited result and criteria for adoption in many other studies. The net returns to labour, (net returns, including paid labour costs, divided by total hours), indicates that both reduced and no-till are roughly equal in value and that both exceed conventional tillage by approximately $52/hour, using current market value for machinery. This means that, on average, a corn producer could choose either (i.e. be indifferent) between reduced and no-till practices, particularly if producers have a high opportunity cost of labour. For many corn producers, this evaluation criteria may be most important for the following reasons:

1. It may provide them an opportunity to buy, rent and farm more land.

2. It may provide an opportunity to devote more time input into other enterprises or activities including leisure.

3. It may provide an opportunity to avoid labour availability or performance problems.

When considering returns to material costs alone per acre, conventional tillage practices exceeded the results for no-till. This occurs because material costs tended to be higher

with no-till and yields tended to be lower compared to conventional tillage.

The results from similar analyses for each year, using trade-in values for machinery, are presented in Tables 6.1c to 6.1e. Given only three years data, it is not possible to identify any discernable trends. It is interesting to note that in 1988 when growing conditions were very dry, returns to no-till were below those of both conventional and reduced tillage practices. In all three years, net returns per acre to reduced tillage practices were highest.

The returns to labour, ([Revenue - TC]/Total hours), were significantly higher for no-till in 1986 and 1987 compared to conventional and reduced tillage practices. Yet in 1988, they were significantly lower than the alternatives, again, largely due to lower yields as a result of drought conditions.

In general, returns to at least some form of conservation tillage appear to exceed conventional tillage practices on corn. However, an additional question may arise which may influence adoption rates: What is the expected probability that conservation practices will pay more compared to conventional - i.e. what is the associated financial risk with each tillage practice?

Table 6.1a Comparison of Average Annual Production Costs and Net Returns for Alternative Tillage Practices On Grain Corn, Combined for 1986 to 1988, Using Purchase Price for Machinery Calculations

	Grain Corn		
	AVERAGE 1 (Conventional)	AVERAGE 2 (Reduced)	AVERAGE 3 (No-Till)
		(dollars per acre)	
Cost of Conducting Operations: (Includes machinery and Custom costs only)		Average 1986 - 88	
Fall Operations	16.73	9.59	1.47
Spring Operations	42.43	39.03	31.66
Harvest Operations	76.52	76.74	74.92
SubTotal:	124.27	116.45	99.04
Material Costs (MA):			
Seed	30.81	29.05	29.49
Fertilizer	48.81	48.81	48.37
Herbicide	22.69	24.18	29.03
Insecticide	3.77	3.43	3.15
SubTotal:	106.38	105.70	110.45
Fuel Costs (FC)	2.47	1.91	1.41
Labour Costs (LC)	8.94	6.99	6.43
Total Costs (TC):	242.05	231.06	217.33
Total Hours	1.30	1.02	0.90
Yield (bu/acre)	118.27	122.00	113.41
Crop Price ($/bu)	3.25	3.25	3.25
Total Revenue	384.39	396.50	368.58
Margin:			
Revenue - MA	278.01	290.80	258.13
Revenue - TC	142.33	165.44	151.24
(Revenue - TC)/Total Hours	109.48	162.20	168.04

Table 6.1b Comparison of Average Annual Production Costs and Net Returns for Alternative Tillage Practices on Grain Corn, Combined for 1986 to 1988, Using Trade-in Value for Machinery Calculations

	Grain Corn		
	AVERAGE 1 (Conventional)	AVERAGE 2 (Reduced)	AVERAGE 3 (No-Till)
		(dollars per acre)	
Cost of Conducting Operations: (Includes machinery and Custom costs only)		Average 1986 - 88	
Fall Operations	11.69	7.78	1.29
Spring Operations	34.91	32.98	27.78
Harvest Operations	70.35	71.20	70.06
SubTotal:	105.53	103.04	91.29
Material Costs (MA):			
Seed	30.81	29.05	29.49
Fertilizer	48.81	48.81	48.37
Herbicide	22.68	24.18	29.03
Insecticide	3.77	3.43	3.15
SubTotal:	106.38	105.70	110.45
Fuel Costs (FC)	2.47	1.91	1.41
Labour Costs (LC)	8.94	6.99	6.43
Total Costs (TC):	223.32	217.65	209.58
Total Hours	1.30	1.02	0.90
Yield (bu/acre)	118.27	122.00	113.41
Crop Price ($/bu)	3.25	3.25	3.25
Total Revenue	384.39	396.50	368.58
Margin:			
Revenue - MA	278.67	290.80	258.13
Revenue - TC	161.07	178.85	159.00
(Revenue - TC)/Total Hours	123.90	175.34	176.67

Table 6.1c Comparison of Average Annual Production Costs and Net Returns for Alternative Tillage Practices On Grain Corn, For 1986, Using Trade-In Value for Machinery Calculations

	Grain Corn		
	AVERAGE 1 (Conventional)	AVERAGE 2 (Reduced)	AVERAGE 3 (No-Till)
		(dollars per acre)	
Cost of Conducting Operations: (Includes machinery and Custom costs only)		1986	
Fall Operations	12.28	7.75	1.13
Spring Operations	26.85	31.34	19.99
Harvest Operations	68.29	74.19	70.05
SubTotal:	96.63	105.07	86.20
Material Costs (MA):			
Seed	28.56	29.33	29.51
Fertilizer	43.78	50.53	57.65
Herbicide	20.48	21.92	25.75
Insecticide	4.43	3.67	6.87
SubTotal:	97.25	105.45	119.77
Fuel Costs (FC)	2.48	1.78	0.99
Labour Costs (LC)	8.31	6.43	3.97
Total Costs (TC):	204.67	218.73	210.93
Total Hours	1.21	0.95	0.59
Yield (bu/acre)	106.65	115.88	109.59
Crop Price ($/bu)	3.25	3.25	3.25
Total Revenue	346.63	376.60	356.16
Margin:			
Revenue - MA	249.38	271.15	236.39
Revenue - TC	141.96	157.87	145.23
(Revenue - TC)/Total Hours	117.32	166.18	246.15

Table 6.1d Comparison of Average Annual Production Costs and Net Returns for Alternative Tillage Practices On Grain Corn, For 1987, Using Trade-In Value for Machinery Calculations

	Grain Corn		
	AVERAGE 1 (Conventional)	AVERAGE 2 (Reduced)	AVERAGE 3 (No-Till)
		(dollars per acre)	
Cost of Conducting Operations: (Includes machinery and Custom costs only)		1987	
Fall Operations	10.98	9.44	2.10
Spring Operations	36.15	32.97	19.28
Harvest Operations	75.08	74.37	74.77
SubTotal:	111.58	106.91	89.71
Material Costs (MA):			
Seed	33.19	28.43	27.55
Fertilizer	53.16	49.98	48.86
Herbicide	27.16	26.25	32.93
Insecticide	2.35	2.56	1.63
SubTotal:	116.55	107.75	112.09
Fuel Costs (FC)	2.29	2.05	1.18
Labour Costs (LC)	8.33	7.83	5.26
Total Costs (TC):	238.75	224.54	208.24
Total Hours	1.20	1.12	0.63
Yield (bu/acre)	134.57	138.45	134.74
Crop Price ($/bu)	3.25	3.25	3.25
Total Revenue	437.35	449.97	437.90
Margin:			
Revenue - MA	320.80	342.22	325.81
Revenue - TC	198.60	225.43	229.66
(Revenue - TC)/Total Hours	165.50	201.28	364.54

Table 6.1e Comparison of Average Annual Production Costs and Net Returns for Alternative Tillage Practices On Grain Corn, For 1988, Using Trade-In Value for Machinery Calculations

	Grain Corn		
	AVERAGE 1 (Conventional)	AVERAGE 2 (Reduced)	AVERAGE 3 (No-Till)
		(dollars per acre)	
Cost of Conducting Operations: (Includes machinery and Custom costs only)		1988	
Fall Operations	12.24	4.66	0.45
Spring Operations	49.39	35.36	49.50
Harvest Operations	62.57	60.86	63.00
SubTotal:	109.39	92.81	100.18
Material Costs (MA):			
Seed	29.56	29.83	32.04
Fertilizer	48.54	44.11	35.34
Herbicide	15.89	23.51	28.22
Insecticide	6.03	4.72	0.22
SubTotal:	100.03	102.17	95.82
Fuel Costs (FC)	2.89	1.85	2.30
Labour Costs (LC)	11.91	6.22	11.27
Total Costs (TC):	224.22	203.06	209.58
Total Hours	1.76	0.90	1.67
Yield (bu/acre)	101.46	99.77	90.07
Crop Price ($/bu)	3.25	3.25	3.25
Total Revenue	329.75	324.24	292.72
Margin:			
Revenue - MA	229.72	222.07	196.89
Revenue - TC	105.52	121.18	83.14
(Revenue - TC)/Total Hours	59.95	134.64	49.78

6.2 Financial Analysis Results of Corn When Maintaining Paired Comparisons

When conducting the forgoing analysis with the paired data, as described earlier, a significant number of fields were dropped out of the analysis for each pair. Specifically, in the comparison of conventional vs. reduced tillage practices, 15 fields were deleted out of a possible combination of 68 fields. For the comparison of conventional and no-till practices, 24 fields were deleted out of a possible combination of 51 fields. Likewise, for the comparison of no-till and reduced tillage practices, 24 fields were also deleted out of a possible combination of 61 fields.

Details of this financial analysis are presented in Tables 6.2a -6.2c, using trade-in values for machinery calculations. Results indicate that the relative difference in net returns per acre between conventional and reduced tillage fields was $15, compared to $12 per acre for conventional vs. no-till. However, it is not accurate to say that reduced tillage practices generated $3 more per acre compared to conventional practices than did no-till, because the mix of fields used in each paired comparison contain a large portion of unique fields.

Results of paired comparisons between no-till and reduced tillage practices indicate that the net returns per acre are roughly equivalent. However, based on the returns per labour hour, no-till exceeds reduced tillage by as much as $106. This is in sharp contrast to the results presented in Table 6.1b, which indicate that reduced and no-till returns per labour hour are equivalent, and that returns per acre are greatest with reduced tillage.

The likely reasons for this difference are as follows:

1) If farmers are currently utilizing reduced tillage practices as their base system, the imposition of no-till practices and the additional management required are likely an easier transition than going from conventional directly to no-till systems. Some may argue that they represent "better" managers as reflected in their willingness to try new innovative approaches, consequently they may be able to take fuller advantage of no-till particularly in the form of reduced labour hours/acre.

2) The utilization of reduced tillage prior to no-till may have pre-conditioned the soil to a conservation environment, thus preventing large yield reductions when no-till was introduced.

This result is applicable only for corn producers going from reduced to no-till situations. It can not be interpreted that, on average, net returns per acre to no-till ere equivalent to reduced tillage or that returns per labour hour are higher.

Despite these minor differences in the results between the two data organization approaches, the overall trends and conclusions remain the same. Namely, conservation tillage practices generate higher returns to producers compared to conventional tillage practices, and that in one situation returns to no-till practices exceed those of reduced tillage, or in all cases are at least equivalent, based on returns per labour hour.

Table 6.2a Comparison of Average Annual Production Costs and Net Returns for Conventional and Reduced Tillage Practices On Grain Corn, 1986-88, Using Trade-In Value for Machinery Calculations

	Grain Corn	
	Conventional	Reduced Tillage
	(dollars per acre) 1986 - 88	
Cost of Conducting Operations: (Includes machinery and Custom costs only)		
Fall Operations	13.08	9.06
Spring Operations	31.98	33.76
Harvest Operations	70.64	71.44
SubTotal:	104.64	104.50
Material Costs (MA):		
Seed	31.29	28.64
Fertilizer	49.73	47.23
Herbicide	23.82	23.72
Insecticide	4.56	4.15
SubTotal:	109.77	104.06
Fuel Costs (FC)	2.48	2.12
Labour Costs (LC)	8.59	7.64
Total Costs (TC):	225.48	218.31
Total Hours	1.25	1.11
Yield (bu/acre)	122.30	125.29
Crop Price ($/bu)	3.25	3.2[illegible]
Total Revenue	397.48	407.19
Margin:		
Revenue - MA	287.70	303.14
Revenue - TC	172.00	188.88
(Revenue - TC)/Total Hours	137.60	170.16

Table 6.2b Comparison of Average Annual Production Costs and Net Returns for Conventional and No Tillage Practices On Grain Corn, 1986-88, Using Trade-In Value for Machinery Calculations

	Grain Corn	
	Conventional	No-Tillage
	(dollars per acre)	
Cost of Conducting Operations: (Includes machinery and Custom costs only)	1986 - 88	
Fall Operations	9.54	1.24
Spring Operations	43.92	33.42
Harvest Operations	74.87	72.45
SubTotal:	117.28	97.33
Material Costs (MA):		
Seed	32.87	29.07
Fertilizer	50.29	49.09
Herbicide	25.84	29.74
Insecticide	2.00	4.00
SubTotal:	111.70	112.54
Fuel Costs (FC)	2.06	1.65
Labour Costs (LC)	8.99	8.12
Total Costs (TC):	240.03	219.64
Total Hours	1.30	1.12
Yield (bu/acre)	122.20	118.67
Crop Price ($/bu)	3.25	3.25
Total Revenue	397.15	385.68
Margin:		
Revenue - MA	285.45	273.14
Revenue - TC	157.12	166.04
(Revenue - TC)/Total Hours	120.86	148.25

Table 6.2c Comparison of Average Annual Production Costs and Net Returns for No-Till and Reduced Tillage Practices On Grain Corn, 1986-88, Using Trade-In Value for Machinery Calculations

	Grain Corn	
	No-Till	Reduced Tillage
	(dollars per acre)	
Cost of Conducting Operations: (Includes machinery and Custom costs only)	1986 - 88	
Fall Operations	1.61	7.72
Spring Operations	21.08	32.88
Harvest Operations	70.75	71.90
SubTotal:	87.75	104.46
Material Costs (MA):		
Seed	29.26	28.63
Fertilizer	49.06	47.97
Herbicide	30.79	27.26
Insecticide	2.40	2.45
SubTotal:	112.07	106.72
Fuel Costs (FC)	1.12	1.51
Labour Costs (LC)	4.57	6.54
Total Costs (TC):	205.51	219.23
Total Hours	0.60	0.93
Yield (bu/acre)	117.38	121.18
Crop Price ($/bu)	3.25	3.25
Total Revenue	381.49	393.84
Margin:		
Revenue - MA	269.42	287.11
Revenue - TC	175.98	174.61
(Revenue - TC)/Total Hours	293.30	187.75

6.3 Financial Risk Analysis for Grain Corn

In general, it appears that two factors most influence the net returns per acre: 1) material costs, and 2) crop yield. The variability around these mean values were quite high. Consequently, it is instructive to incorporate these sources of variation directly in the analysis in order to conduct an assessment of the relative financial risks associated with each tillage practice. This was accomplished with aid of Monte Carlo simulation, a modelling routine available within IFPS. The mean and standard deviation for yields and material costs, for each tillage practice, used in the Monte Carlo Simulation are presented in Annex 6.3.

Results of the Monte Carlo simulation analysis, using current market value for machinery, are summarized in Table 6.3, for the average of 1986-88 for each tillage practice. In this table, the 90% confidence range for the net returns per acre and returns to labour are presented. Specifically, the low, mean, and high values of the 90% confidence range are presented. The appropriate interpretation is as follows:

1. At the low end, there is a 90% probability that a corn producer will obtain a net return per acre of $39, $46, and $39 or greater for conventional, reduced, and no-till practices respectively.
2. At the mean point, there is 50% probability of obtaining a value greater than $157, $173, and $156 respectively.
3. At the high end of the distribution, there is a 10% probability of obtaining a value greater than $275, $300, and $272 respectively.

It is evident that for the average net return per acre, (Revenue - Total Cost of Production), that financial risks associated with reduced (minimum) tillage are significantly

lower compared to conventional and no-till practices, as per the 90% confidence range of possible net results. In addition, the financial risk associated with conventional and no-till practices are relatively equal, using this marginal analysis criteria. This means that, based on net return per acre, no-till practices on corn will not be any riskier than conventional practices, when averaging over the three years. This result complements the conclusion made previously about these two tillage practices.

However, the above calculation does not consider the opportunity cost of labour, viz. the return to labour, (net returns per acre divided by hours per acre), (see Table 6.3). In this case, both reduced and no-till practices are far lower risk than conventional tillage practices. Indeed, based on returns to labour, the risk analysis indicates that a corn producer could be indifferent between choosing minimum or no-till practices. Again, this criteria will be most important for corn producers with a high opportunity cost of labour.

Table 6.3 Expected Net Returns Per Acre, on Grain Corn, From Alternative Tillage Practices at the 90% Confidence Level, Averaging 1986-88, Using Trade-In Value for Machinery

Net Returns (Revenues - TC) per Acre

Tillage Practice	90% Confidence Range Low	Mean (dollars)	High
Conventional	39	157	275
Reduced (Minimum)	46	173	300
No-Till	39	156	272

Returns to Labour = (Revenue - TC)/Hours per Ac

Tillage Practice	90% Confidence Range Low	Mean (dollars)	High
Conventional	30	120	211
Reduced (Minimum)	45	169	294
No-Till	43	173	302

Source: DH&S - Monte Carlo Simulation

6.4 Other Crops

6.4.1 Soybeans

Over the three year data period, 13 cooperators experimented with the introduction of alternative tillage practices on 45 fields of soybeans. The distribution of data representing field input/output results over the study period is as follows:

	1986	1987	1988	TOTAL
1. Conventional	3	3	8	14
2. Reduced Tillage	4	3	12	19
3. No-Till	3	2	7	12
Total	10	8	27	45

Compared to grain corn, the amount of field data for soybeans is considerably less, with an uneven distribution over the study period.

Given the scarcity of observations, only the average results for the study period, (1986-88), are summarized below in Table 6.4.1 using trade-in values for farm machinery.

It is evident, in terms of the net returns per acre, that financial returns to conventional tillage exceed those of both reduced and no-till practices, by $7 and $68 per acre respectively. However, the difference between conventional and reduced (minimum) tillage practices is very marginal and may not be statistically significant. Clearly, net returns per acre for no-till practices tend to be far below its alternatives. It is our understanding that the main reason for this result, is that soybeans are more sensitive to weed competition compared to corn, and with conservation practices

more weed pressure is possible.

When considering the returns to labour, on the other hand, reduced (minimum) tillage practices exceed the returns for conventional tillage by as much as $17/hour. Again, this evaluation criteria may be most important for some soybean producers, for the same reasons outlined previously for corn.

6.4.2 Barley

Seven barley producers cooperated with Tillage 2000 at various points throughout the study period to generate 16 fields of input/output data. The distribution of data among the tillage practices is presented below:

	1986	1987	1988	TOTAL
1. Conventional	2	3	2	7
2. Reduced Tillage	1	1	2	4
3. No-Till	1	2	2	5
Total	4	6	6	16

Due to the limited number of field observations, only the average annual results combined for 1986 to 1988 are analyzed. The average results for the study period for each tillage practice on barley are presented in Table 6.4.2, using trade-in values for farm machinery only.

Table 6.4.1 Comparison of Average Annual Production Costs and Net Returns for Alternative Tillage Practices on Soybeans, Combined for 1986 to 1988, Using Trade-in Value for Machinery Calculations

	Soybeans		
	AVERAGE 1 (Conventional)	AVERAGE 2 (Reduced)	AVERAGE 3 (No-Till)
		(dollars per acre)	
Cost of Conducting Operations: (Includes machinery and Custom costs only)		Average 1986 - 88	
Fall Operations	12.81	9.36	0.45
Spring Operations	28.08	26.93	24.55
Harvest Operations	31.68	34.25	34.28
SubTotal:	61.07	61.10	51.64
Material Costs (MA):			
Seed	25.64	21.53	25.90
Fertilizer	11.49	14.76	9.59
Herbicide	40.93	36.71	64.21
Insecticide	0.05	0.04	0.00
SubTotal:	78.74	73.49	99.70
Fuel Costs (FC)	2.28	1.91	1.44
Labour Costs (LC)	9.21	7.52	6.19
Total Costs (TC):	151.30	144.03	158.98
Total Hours	1.36	1.11	0.90
Yield (bu/acre)	41.12	39.09	32.67
Crop Price ($/bu)	7.10	7.10	7.10
Total Revenue	291.96	277.54	231.93
Margin:			
Revenue - MA	213.23	204.04	132.24
Revenue - TC	140.66	133.51	72.96
(Revenue - TC)/Total Hours	103.43	120.28	81.07

Table 6.4.2 Comparison of Average Annual Production Costs and Net Returns for Alternative Tillage Practices on Barley, Combined for 1986 to 1988, Using Trade-In Value for Machinery Calculations

	Barley		
	AVERAGE 1 (Conventional)	AVERAGE 2 (Reduced)	AVERAGE 3 (No-Till)
		(dollars per acre)	
Cost of Conducting Operations: (Includes machinery and Custom costs only)		Average 1986 - 88	
Fall Operations	13.43	3.70	4.46
Spring Operations	17.39	27.15	19.42
Harvest Operations	26.84	33.96	22.42
SubTotal:	44.64	54.29	38.93
Material Costs (MA):			
Seed	16.87	14.48	13.32
Fertilizer	25.82	25.10	23.56
Herbicide	1.25	13.23	20.01
Insecticide	2.37	0.00	0.00
SubTotal:	46.31	52.81	56.88
Fuel Costs (FC)	2.92	1.83	2.06
Labour Costs (LC)	10.11	8.69	5.31
Total Costs (TC):	103.97	117.62	103.18
Total Hours	1.50	1.29	0.79
Yield (bu/acre)	44.73	49.98	37.08
Crop Price ($/bu)	2.70	2.70	2.70
Total Revenue	120.77	134.93	100.12
Margin:			
Revenue - MA	74.45	82.13	43.23
Revenue - TC	16.79	17.32	-3.06
(Revenue - TC)/Total Hours	11.19	13.43	-3.87

Results of the analysis of net returns per acre for barley indicate that reduced tillage practices tend to generate equivalent returns compared to conventional practices, (i.e. only a difference of less than $1/acre). However, given these results, a barley producer should be indifferent between conventional and reduced (minimum) tillage practices based upon this evaluation criteria. The net returns per acre for no-till were significantly below the alternatives, by as much as $20/acre.[6]

In this case, the returns to labour are approximately the same for conventional and reduced tillage practices, with only a slight advantage for reduced tillage, (i.e. just over $2/acre). It is likely that this small difference is statistically insignificant given the degree of variability in the data.

6.4.3 Winter Wheat

For winter wheat production, 8 cooperators generated 19 fields of input/output data for 1986 and 1988 with the following distribution over the three tillage practices:

	1986	1987	1988	TOTAL
1. Conventional	1	0	2	3
2. Reduced Tillage	3	0	4	7
3. No-Till	4	0	5	5
Total	8	0	11	19

[6] Although the absolute results for no-till are negative compared to the alternative tillage practices, it would be incorrect to interpret that no-till practices on barley result in a loss of revenue. Rather, the important measure for this and other crops is the relative difference between results among the alternative tillage practices.

Unfortunately, no field data for 1987 was available for this analysis.

Given the scarcity of observations, only the average results for the study period, (1986-88), are summarized below in Table 6.4.3, using trade-in values for farm machinery only. Results of the financial analysis indicate that the net returns per acre for no-till practices exceed returns from both conventional and reduced tillage practices, by as much as $73/acre and only $3/acre, respectively. Returns from reduced tillage exceed those from conventional tillage by $70/acre. Consequently, the use of any kind of conservation tillage practice on winter wheat results in significantly higher net returns per acre compared to conventional practices.

Using the alternate economic measure of financial return - returns to labour, the results are similar in direction but differ in magnitude. Specifically, returns per hour for no-till exceed those of reduced tillage by as much as $55/hour, and exceed conventional tillage by as much as $162/hour (Table 6.4.3). Consequently, wheat producers with high opportunity costs of labour would benefit most from adopting no-till tillage practices over conventional practices. This is the most positive result for no-till practices compared to the other crops evaluated.

Table 6.4.3 Comparison of Average Annual Production Costs and Net Returns for Alternative Tillage Practices on Winter Wheat, Combined for 1986 to 1988, Using Trade-In Value for Machinery Calculations

	Winter Wheat		
	AVERAGE 1 (Conventional)	AVERAGE 2 (Reduced)	AVERAGE 3 (No-Till)
		(dollars per acre)	
Cost of Conducting Operations: (Includes machinery and Custom costs only)		Average 1986 - 88	
Fall Operations	31.76	8.83	1.80
Spring Operations	6.58	12.39	14.74
Harvest Operations	31.10	30.19	31.31
SubTotal:	60.15	45.31	43.47
Material Costs (MA):			
Seed	30.75	31.23	28.78
Fertilizer	65.21	50.76	46.77
Herbicide	11.93	1.86	4.94
Insecticide	0.00	0.00	0.00
SubTotal:	107.88	83.86	80.49
Fuel Costs (FC)	2.12	1.42	1.04
Labour Costs (LC)	7.18	4.68	3.34
Total Costs (TC):	177.33	135.28	128.34
Total Hours	1.06	0.69	0.49
Yield (bu/acre)	49.67	57.01	56.03
Crop Price ($/bu)	3.80	3.80	3.80
Total Revenue	188.73	216.65	212.93
Margin:			
Revenue - MA	80.85	132.79	132.44
Revenue - TC	11.40	81.38	84.59
(Revenue - TC)/Total Hours	10.75	117.94	172.63

7.0 GENERAL DISCUSSION OF TILLAGE 2000 RESULTS

From the foregoing analysis of Tillage 2000 field data for 1986 to 1988, a number of general observations and conclusions can be made:

1) The data management system designed to facilitate the coordination and manipulation of field level data performed well, and provided necessary calculations as input to the financial simulation. This is an important element in our program since it is anticipated that large volumes of field data will be provided over the course of the SWEEP-PDW project, and a logical system to manage this data is necessary.

2) Some of the Tillage 2000 data was either missing or presented in a form that resulted in confusion during interpretation. Minor adjustments to the data collection and recording procedure for Tillage 2000 would be useful.

3) The adoption of reduced (minimum) tillage practices produced generally higher yields and higher net return per acre in corn, barley and winter wheat. In soybeans, yields and net returns were marginally lower than conventional practices. The consistency of reduced tillage, across all crops, in this regard is very evident and positive.

4) No-till practices typically resulted in marginally lower yields and higher input costs per acre. At the same time significant machinery and labour savings resulted in significantly higher net returns per acre compared to conventional and reduced tillage practices in winter wheat, and equivalent net returns from conventional

practices on corn as well.

5) When considering the returns to labour, however, no-till and reduced tillage practices tended to generate equivalent results particularly for corn. However, in winter wheat returns to labour with no-till exceeded reduced and conventional tillage practices by $55/hour and $162/hour, respectively.

6) The financial risk analysis for alternative tillage practices on corn indicates that reduced tillage is the least risky and that conventional and no-till practices are equivalent, with respect to net returns per acre. However, with respect to returns to labour, no-till is least risky compared to reduced and conventional tillage practices.

7) For soybeans only, it appears that conventional tillage practices generate higher net returns per acre compared to current reduced or no-till practices, however, the difference between conventional and reduced is marginal and likely not significant.

8) Using the returns to labour criteria for soybeans, reduced tillage provided higher returns compared to conventional tillage practices.

9) The use of "paired" or "unpaired" Tillage 2000 data for corn provided similar results, and did not affect the general conclusions of the economic analysis.

10) There is perhaps no ideal way to incorporate a calculation of machinery costs into an evaluation of net returns to alternative practices, particularly when

comparing field based demonstration plots. For example, the same basic equipment, (tractors for example) used for key tasks in each tillage practice. In an operating situation the individual farmer may well be able to alter his equipment complement to the changed requirements.

Additionally, the calculation of machinery costs was based on an hourly cost calculation. Even if the equipment is used less the actual total depreciation and finance cost could stay the same depending on the farmer's replacement policy and hence provide a limited saving on equipment costs. If farmers are able to extend the life of their equipment through lower usage levels, then they could achieve lower equipment costs through a no-till system. Consequently, equipment cost savings will depend on each farm situation and no amount of calculation of average or synthesized equipment and cost calculations will determine the impact on machinery cost on each farm situation.